Workshop on use of global teleconnection patterns for weather/climate forecasting: Weeks 1-3

Where: ESRL/PSD Boulder, Colorado

When: Tuesday, February 24, 2009

The workshop is geared toward weather-climate forecasters who prepare week 1-3 predictions on a daily basis. The purpose is to introduce a multi-pronged forecast process that combines statistical and numerical model predictions with synoptic interpretation and dynamical diagnosis. The workshop will concentrate on the latter aspect using a global monitoring approach proposed by Weickmann and Berry (WB, 2007; 2009). Bridging weather and climate remains elusive; however, the approach involves a preliminary effort to link synoptic weather systems, global subseasonal variations and the slow ENSO cycle. A regional emphasis is on the Asia-Pacific-Americas sector.

Subseasonal variability occupies a unique niche in weather-climate studies, and is a focus of the workshop. There are at least two slow subseasonal phenomena that engage global teleconnection patterns. One is the well known Madden-Julian Oscillation (MJO), a 30-60 day signal in *tropical* convection that propagates from the Indian Ocean out into the Pacific and western hemisphere. Less known is the global wind oscillation (GWO; WB, 2009), which is derived from a *global* average of the zonal wind or relative atmospheric angular momentum. Its primary forcing is from mountain and frictional torques but momentum transports involving mid-latitude eddy processes play an important indirect role. Together the MJO and GWO provide a big picture assessment of both tropical and extratropical variability, which can then be used in the week 1-3 forecast process.

Logistics

The workshop will be held at the David Skaggs Research Center (DSRC) in Room GC402. DSRC is located at 325 Broadway on the Federal Campus in Boulder, Colorado. Security requires visitors obtain a badge with a government issued identity card (e.g., drivers license) for US citizens and a green card or visa for foreign nationals (contact barbara.s.herrli@noaa.gov if you are a foreign national). It will take about 15 minutes to get a visitors pass. We will provide more information about security procedures when the number of attendees becomes known. Boulder is located about 45 miles from Denver International Airport (DIA), and there are shuttle services that can bring you here. If you rent a car, it takes about 50 minutes to drive the distance in non-rush hour traffic. There is a toll route that is faster and costs $6.50. Bus service is also available from DIA to downtown Boulder for $12. There are number of hotels to choose from in the area including the Millennium Harvest House Boulder, Hotel Boulderado, Best Western Golden Buff, Homewood Suites Boulder CO, etc.

For additional information see:

http://www.esrl.noaa.gov/about/visiting.html

If you have questions, please contact either klaus.weickmann@noaa.gov or edward.berry@noaa.gov.

If you have not already done so, please send either one of us an email confirming your plans to attend the workshop.

Expanded Outline

1. Introduction

a. There is limited skill, but forecasts of opportunity arise

- Linear inverse modeling (LIM) using 7-day means with 38 degrees of freedom (dof) shows good skill predicting weather patterns weeks 1-4. The approach helps define the space-time evolution of MJO/GWO/ENSO/PNA/SST and also provides information on the source of skill. A predictability study suggests additional skill is possible weeks 1-4 but it is modest.
- Our approach using the global synoptic dynamic model (GSDM) also relies on MJO/GWO/ENSO/PNA/SST, which are monitored and diagnosed in real-time using indices and composites. There are ~3 spatial dof in our MJO+GWO global indices, and they include multiple time scales from synoptic to subseasonal to ENSO, as well as different behaviors from oscillatory to red and white noise.
- By combining the above two approaches with global numerical prediction models, we are proposing a dynamical weather-climate linkage framework for subseasonal predictions. Our goal is to diagnose the dynamics of the global land-ocean-atmosphere system focusing on subseasonal variations along with interactions involving slower behaviors like ENSO and faster processes like extreme weather events.

b. Although atmospheric signals are weak, it beats diagnosing the market!

- To get perspective, it is instructive to compare the main component of the global wind oscillation, AAM, with the DJIA (Dow) – an index of another noisy system. The Dow measures the value in a financial system while AAM measures the westerly flow in the atmospheric system.
- The simplest linear model for each system, much simpler than LIM, is geometric Brownian motion for the Dow and simple Brownian motion for AAM. The geometric part comes from accounting for the upward trend in the Dow. Let's compare the statistics of the daily AAM tendency and the daily Dow return to see how/if the models apply.
- Neither probability density function (pdf) is Gaussian, especially the Dow (hedge!); expect higher probability of extreme events. Strike one for the models, which say the pdf is Gaussian. The frequency spectrum of the Dow daily return is white (model OK), but the AAM spectrum is red with some bumps (AAM model strikes out, there is hope!). So, it may be useful to diagnose signals in the weather-climate system but there's not much point to diagnosing the daily Dow returns. However, markets are not completely uninteresting. For example, there's the business cycle and volatility, which could be equated to ENSO/PDO and synoptic activity.
- Beyond a single index like the Dow or AAM, we have multivariate processes that can be modeled by a linear auto-regressive, lag 1 (AR1) process like LIM, or by full-blown nonlinear dynamical models. All models have errors with the latter's being particularly stubborn. Synoptic monitoring and dynamical diagnosis is one way to deal with model error and increase prediction skill in the atmosphere. This is the focus of the workshop.

2. MJO and GWO Fundamentals, and Monitoring

a. Aspects of global dynamics, brief description

- Rossby wave primer
- Introduction to multiple time scales; ex., global Rossby modes, fast vs. slow decay times, etc.
- Equilibrium response to tropical forcing in a simple atmosphere, Rossby wave dispersion
- Baroclinic life cycle and wave breaking
- Coherent tropical OLR modes: "bumps" on a red noise background, what about the background?
- Mountains, synoptic wavetrains and meridional AAM transports
- Schematics of MJO, GWO, RWD
- Poleward movement of zonal mean zonal wind anomalies, link with torques
- Sea surface temperature versus atmospheric dynamics

b. Why "only" the MJO and GWO?

- Useful “repeatable” signals, quasi-oscillatory vs. red noise, slowly evolving and coherent enough to extract predictable information
- Spectra show different time behavior but in same frequency band (GWO1, RMM1)
- Forecasts of opportunity; proactive (ex., 11/22/08) vs. reactive skill (1/3/09)
- Most times a mixture, sometimes one or the other signal stands out
- teleconnections

c. Phase spaces to track phenomena

- Keep track of phase/amplitude of a phenomenon, either oscillatory or not
- GWO – mixed time scales; fast, synoptic related to wave energy dispersion (changing wave tilts) and slow, global related to meridional AAM transports
- Composite trajectories of the MJO and GWO with annotations, evidence for subseasonal “ENSO” attractors

d. MJO and GWO composites

- Global to zonal mean to regional scale linkages
- Web-based standardized composites of 250mb streamfunction, outgoing radiation and 2m air temperature
- Models and predictability; ex., 8-1-2 phase transitions

3. Using the MJO and GWO in real time: ONDJ 2008-09

a. Indications that La-Nina “was back”; never left?

- Anomalous easterly wind flow anomalies in the subtropical atmosphere
- Low AAM with zonally asymmetric, La Nina tropical circulation anomalies
- Anomalously cool SSTs equatorial date line
- La-Nina “imprint” in the atmosphere since December 2006

b. Synopsis of recent weather-climate behavior

✓ A “truncated” October 2008 MJO and two ~30 day GWO orbits (Oct and Nov 2008) presented a forecast of opportunity in mid/late November 2008. We expected retrogression of the west coast ridge and a cold/wet regime focusing on the western half of the USA. Models were struggling (8-1-2 transition). During this time Nino SSTs began responding to an atmosphere that had significant residual La-Nina characteristics. The forecast worked out, and was made well before anything “official” or model based. This is an example of making a proactive prediction.

✓ The faster GWO variations (in this case “trapped” subtropical wavetrains?) subsequently perturbed the well defined La-Nina base state, and led to an eastward shift of convection, and of upper level anticyclones to the west Pacific ~24 December. This excited a meridionally directed RWD across the PNA sector by late December that initially favored troughing across the western states. The shift of convection coincided with a slow, seasonal (?) eastward propagation of tropical convection from ~100 to 140E from late November to early January 2009. A feedback we did not anticipate was the emergence of a strong MJO signal from the Indonesian region. The MJO was preceded by a southward transport of zonal momentum across 35N (~20-27 Dec), which probably contributed to exciting the MJO and which in turn can be traced back to the fast GWO variations of October and November.

✓ As the MJO moved east, jet streams extended across the Pacific in two episodes (7-20 Jan), the second one leading to a westward shifted +PNA and a severe central USA cold air outbreak. Interestingly, most models starting with ~23 December 2008 initial conditions predicted a +PNA with 10-14 days lead-time. The same models, however, were not amplified enough with the second extension and too far east with the PNA ridge. The severity of the cold was predictable with about 5 days (~9 January) lead-time. This is an example of being reactive to the “rogue MJO signal”, and providing useful updated forecast information.

✓ On 3 January, Ed Berry in his blog proposed a PNA retrogression in ~10-20 days. Instead, this is occurring 20-25 days after 3 Jan. The MJO was clearly important, and contributed to the timing error. The initial retrogression is being forced by residual Indonesian (La-Nina) convection. The more robust convective forcing is likely later (written 1/22/09) week-2 and week-3 once the MJO intensifies over the Indian Ocean and "reloads" La-Nina. Models are again badly struggling as the GWO/MJO evolves through a phase 8-1-2 transition.

c. Proposed forecast process

- What do we look at?
- An important aspect is to evaluate intelligently all numerical and statistical model tools using real-time data within a dynamical weather-climate linkage framework
- Subseasonal predictions, including possibilities of extreme weather events, should be expressed probabilistically, and verified accordingly

4. Towards statistical and numerical prediction

a. GWO: LIM and PSD ensemble

- LIM "singular vectors" and the GSDM
- GWO forecast skill by the PSD ensemble

b. MJO: Linear models and multiple GCMs

- Coupled LIM
- MJO simulation in current models

5. Vision – "the earth is not flat!"

- Global operational centers apply their local expertise; however, they are versed in and can discuss the evolving global circulation patterns
- Bring science back into weather-climate prediction; current efforts are primarily modeling/engineering
- No university training on global coherent evolutions; the GWO should be taught in undergraduate atmospheric dynamics
- Zonal mean chi-problem to diagnose tropical versus mid-latitude eddy momentum transports. Separate [u] (φ, p) budget into divergent mass circulations and eddy flux convergences
- **GOAL:** The weather-climate linkage component is currently lacking as part of the forecast process for preparing subseasonal predictions. A web-based site providing forecasts from multiple sources, including global dynamical models, statistical models and monitoring/diagnosis, would address this problem. All tools should be available in real time with storage and access to previous forecasts. This is the type of information weather sensitive users desire, private and government.

Acronyms:

LIM (linear inverse model)
MJO (Madden-Julian oscillation)
GWO (global wind oscillation)
ENSO (El Nino Southern Oscillation)
PNA (Pacific North American pattern)
SST (sea surface temperature)
AAM (atmospheric angular momentum)
PSD (Physical Sciences Division of ESRL)
WB, 2007 (Weickmann, K.M., and E. Berry, 2007: A synoptic-dynamic model of subseasonal atmospheric variability. *Mon. Wea. Rev.,* **135,** 449-474.)
WB, 2009 (Weickmann. K.M. and E. Berry, 2009: The tropical Madden-Julian oscillation and the global wind oscillation. *Mon. Wea. Rev.*, in press.)
OLR (outgoing longwave radiation)
PDO (Pacific Decadal Oscillation)